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of even minor troponin elevations (5). Maybe the time for diagnostic criteria revision is coming.

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Reply

The apparent paradox of discrepant results of biomarker measurements after percutaneous coronary intervention (PCI) has added further confusion to our limited understanding of myocardial injury that occurs during revascularization. In patients with complex multivessel disease, this myocardial injury occurs equally during either coronary artery bypass graft surgery or PCI despite contemporary procedural technique (1). Myocardial injury during PCI may be either adjacent, caused by occlusion of small side branches during stent implantation, or downstream/distal, caused by embolized atheroma/thrombotic material (2).

Our recent data suggest that higher levels of troponin elevation correlate well with creatine kinase-myocardial band (CK-MB) elevation after PCI (3), and we have previously shown that these biomarker elevations reflect areas of myocardial infarction demonstrable with cardiac magnetic resonance imaging (4). However, in patients with lower levels of troponin elevation after PCI, CK-MB is unlikely to be elevated. In these patients, there is limited evidence of systemic inflammation and no evidence of myocardial infarction on magnetic resonance imaging.

When undertaking analyses of the clinical implication of these smaller troponin elevations after PCI, we should exclude the potential bias of the higher troponin elevations, which, in my opinion, have a clear prognostic consequence. Recently, Cavallini et al. (5) have confirmed that smaller elevations of troponin after PCI (when CK-MB is normal) are principally a reflection of the patient's baseline risk profile and that the prognostic impact is

marginal. In my opinion, this particular clinical scenario of normal CK-MB with small troponin rise would be best categorized in the less emotive category “procedural necrosis” rather than “myocardial infarction.”

Consequently, I agree with the recommendation of Lippi and Cervellin that a change in the arbitrary threshold for procedural infarction when measuring troponin after PCI would be useful. This change in the “universal definition” may allow us to steer safely between Scylla and Charybdis toward a better understanding of revascularization injury and perhaps, ultimately, to the destination of abolishing it.

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“Universal Definition” Methodology and Conclusions Are a Concern

We congratulate Lim et al. (1) on their recent paper assessing this area relevant to clinical practice, especially in light of sensitive cardiac troponin (cTn) assays. However, we have important concerns over the methodology and conclusions.

First, it seems inappropriate to use an insensitive test, late gadolinium enhancement cardiac magnetic resonance (CMR), as a gold standard diagnosis, to compare a sensitive test, cTn, with a moderately sensitive test, creatine kinase-myocardial band (CK-

MB). Cardiac magnetic resonance is considered the gold standard for quantification of ventricular volumes and global and regional function/mass (2). It also allows detection of at least as small as 0.3 g of myocardial infarction (3), if the tissue damage is sufficiently confluent to cause an imaging abnormality (4). It is difficult to assess the volume of myonecrosis corresponding to 3 times the 99th percentile of cTn, which, if due to plaque embolization, is not confluent. The results from Lim et al. (1) and others (3) suggesting a lack of agreement between CMR and cTn for the diagnosis of small-size periprocedural myocardial infarction could all be because of these differences. Our suggestion is that cTn should have been used to diagnose myocardial infarction type 4a, and then CMR would be the investigational test to be compared against that gold standard (5). If so, it might have suggested the insensitivity of CK-MB.

Second, the study showed a comparable area under the receiver-operating characteristic curve for cTn and CK-MB for detection of CMR late gadolinium enhancement (0.985 vs. 0.970, $p = 0.411$). How possibly does this justify their statement to favor one marker over the other?

Third, multiple studies have unequivocally shown that pre-procedural cTn elevation is a powerful independent predictor of death after percutaneous coronary intervention (6). We would suggest not to argue with death as an endpoint. Therefore, disregarding cTn because of its “over-sensitivity,” and preferring the less sensitive marker CK-MB, is not advisable.

In our opinion, rather than using CMR and cTn synergistically (7), this paper inappropriately had 1 play against the other to hide an unpleasant truth: contemporary complex percutaneous coronary intervention results in periprocedural myocardial infarction in many patients. Hiding or ignoring this important observation may withhold important benefit from our patients that could be achieved by research focused on avoiding periprocedural myocardial infarction.

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Reply

The “universal definition” of myocardial infarction (MI) categorizes increasing evidence of myocardial injury during percutaneous coronary intervention (PCI) as either no evidence of injury, evidence of procedural necrosis, or evidence of type 4a MI (1). The thresholds for biomarker abnormality to differentiate between these categories were arbitrarily chosen. Our paper shows that an important difference is evident in these thresholds when measuring either creatine kinase-myocardial band (CK-MB) or troponin (2).

I agree that cardiac magnetic resonance (CMR) imaging with late gadolinium enhancement is the most sensitive imaging modality for detection of focal myocardial injury, and we have previously shown, using this technology, that we can detect evidence of PCI-induced downstream plaque embolization and associated myocardial necrosis (3). In my opinion, setting the arbitrary threshold for diagnosis of MI at the currently defined CK-MB threshold, which is approximately the lower limit of detection by CMR, is both appropriate and pragmatic.

Using this threshold, either CK-MB or troponin can be measured post-procedurally (with an appropriately adjusted threshold for troponin-based MI categorization), and measurements reaching this level and categorization would agree with the general public's perceptions of and implications of the diagnosis of MI. Smaller levels of troponin elevation that are below the sensitivity of CMR to detect injury can be categorized as procedural necrosis.

To use evidence of any troponin elevation as a threshold for diagnosis of MI would make most periprocedural MI invisible to state-of-the-art magnetic resonance imaging and almost universal during revascularization, particularly in the era of the newer, highly sensitive troponin assays. Addressing this issue was one of the principal aims of our paper, as patients with minor elevations of troponin but no evidence of late gadolinium enhancement and normal CK-MB would surely be better categorized as having evidence of PCI-related myocardial necrosis instead of MI? That would be more readily explicable to our patients, and consistent with our data showing minimal inflammatory response in this group and recently published prognostic data (4).

It is increasingly clear that the principal benefits of revascularization are seen when ischemia is abolished. A degree of myocyte